THE

JOURNAL

OF

Nervous and Mental Disease

Vol. III. APRIL, 1876. No. 2.

Original Articles, Selections and Translations.

ART. I.—GENERAL STRUCTURE AND MODES OF ACTION OF THE NERVOUS SYSTEM.*

Necessity for having a general plan of the nervous mechanism—Not such as is usually found in works on anatomy and physiology—Relations of the nervous system at its peripheral and cephalic terminations—Mode of association of these extremes—Nervous system consists of two halves—Peculiarities of their association in different parts of their course—Unilateral actions—Bilateral actions—Extent and relations of the motor (kinesodic) and sensory (esthesodic) tracts, in the peripheral, spinal cord, medulla, etc., and cranial portions—Relations of these tracts in the cerebrum, of sensory tract to emotion and sense perception, of the motor tract to the will—Division of gray nervous matter—Cortex, basal ganglia—Gray tube—Cerebellum—Peripheral ganglia—Relations of these divisions to each other—Systems of fibres, etc., etc.

GENTLEMEN: The past few lectures, I have been occupied in giving you an account of the microscopic constituents of the nervous system, such as its peculiar cells and fibres, its neuroglia and connective tissue.

These are but the bricks, timber, and mortar, as it were, used in building up that singular organism or mechanism, which we call the Nervous System.

It is my purpose, next in order to make you acquainted with the *general plan* of structure, according to which the microscopic elements are disposed. It should be, one of the chief endeavors of the anatomist and physiologist to obtain, as far as possible, a correct knowledge of the mutual relations of all parts of the nervous system, from its most peripheral to its most central portions.

*There will be three of these lectures. In substance they were given in course at the Chicago Medical College during the session of 1875-6.

It is greatly to be desired that we should be able to trace the course of a sense impression, from any part of the periphery of the body, along a sensory nerve to the cord, for example, and from thence its exact course in the cord, through the medulla, up to the basal ganglia, and on to the cortex of the brain, and then to be able to point out what special parts, if any, are the seats of sensibility or of sense perception, and what parts are the immediate seats of particular classes of volitions; and then in the case of voluntary muscular action, to be able to follow the motor impulse along its appropriate track to the basal ganglia, and so on downwards to the pons, medulla and cord, and outward to the periphery of the body.

It will be my object in the next few lectures to place before you, what seem to me to be the most probable views as to the plan of the nervous mechanism, premising, however, that many parts of the plan which I will set before you, are as yet hypothetical, and may have to be either modified or rejected, in the farther progress of neurological science.

It will not be possible for me to enter in a profitable manner into a history of progress, in this respect, nor to refer articulately to sources of information. Without making any pretensions to originality, I will give you what seem to me to be the most probable views, with special reference, however, to results of the labors of Meynert, of Vienna, and Luys, of Paris, and their students, whose works are only beginning to be appreciated as they deserve.

In the very beginning of your studies, it is necessary for you to obtain comprehensive general notions of the nervous system, otherwise you will not be able to understand the relations of the morbid phenomena that are to be referred to hereafter. And if I am able to accomplish nothing else, I shall endeavor to place before you as clear notions as I can in regard to the structure and modes of action of the nervous system.

The time has long since passed by, when ignorance of anatomy and physiology on the part of medical men, can be tolerated with patience, more particularly, with reference to the nervous system. To understand in a rational manner its numerous diseases, a comparatively thorough knowledge of its anatomy and physiology, is absolutely indispensable. There

is no other way. Hence, I cannot and will not proceed a single step with what are called "practical matters" until I feel reasonably certain that you have clear, general notions on this subject.

Without such notions, you will be utterly without a clue to the veritable labyrinth which you are about to enter. But without further preliminary, I will begin with my subject.

In the higher animals, especially man, the nervous system is, without question, the most elevated and important part of the body. This is shown by its central position, its delicacy and perfection of structure, as compared with other organs, the care taken in protecting it from injury, by the dominant influence which it exerts over most of the subordinate parts of the body, and above all, by its intimate relations to the mind, of which, it is the immediate bodily instrument.

The nervous system is divided, for the sake of convenience, into two parts, a central and a peripheral. The former, comprises the continuous mass of nervous substance, which is contained in the cerebro-spinal axis, and consists of the spinal cord and brain, and certain intermediate parts. The latter, comprises not only the cerebral and spinal nerves from near their points of emergence from the cerebro-spinal axis, to their peripheral terminations, but also the so-called sympathetic or vaso-motor system.

The nerve cells, and fibres of the former, are collected into one continuous or concrete mass, while the elements of the latter are discrete, or widely separated, as regards space relations. In the central nervous system, the nerve cells and fibres are closely massed together, so as to form continuous tracts of either, in which intimacy of association is clearly manifested, while in the peripheral nervous system, nerve fibres are often widely separated from each other, as well as nerve cells, which latter, instead of being massed together, as they are in the brain and cord, are sown broadcast throughout the body either in small ganglia, or as solitary cells,—the so-called "ganglion cells,"—being found in close proximity to the parts dependent on them.

Cells predominate perhaps, as compared with fibres, in the central nervous system, while the contrary prevails in the peripheral nervous system.

At one pole or extremity, the nervous system establishes the closest anatomical and physiological relations with most of the various tissues of the body, of which it is a part, while at the other pole or extremity, it is shut in, and defended from outward influences, and has no immediate connections, whether anatomical or physiological, with the rest of the body, and hence, not with the outer world. This hidden and royal part of the nervous system, which is known as the brain,—more particularly, the cerebral hemispheres,—is in immediate relation with what we call mind. But these two extreme parts of the nervous system have numerous and close relations with each other, through certain intermediate, nervous organs, such as the cord, medulla, pons, etc., as will be more fully described hereafter. But it must not be supposed on the one hand that the peripheral and central nervous systems, are anatomically or physiologically separate, nor on the other, that they do not enjoy a certain degree of independence of each other.

The nervous system forms a continuous whole, in which its various parts, however much they may be dependent on their mutual relations, have a sphere of their own, which in many cases, they may and do occupy without reference to the condition of neighboring parts. The most convincing proofs of this latter statement will be afforded as we pass along.

Another fact of importance is this: The nervous system belongs to the class of organs, called symmetrical by morphologists, viz.: it consists of two lateral halves, which for practical purposes, perfectly resemble each in structure and action. In most parts of the nervous system, the two halves may act separately. This seems to be true of both the cord and brain, as well as of the peripheral nervous system, but does not seem to be to the same extent true, if at all, for the medulla and closely related parts.

Normally bilateral actions, such as breathing, speaking, swallowing, etc., are probably excited and controlled from the last named parts, while naturally unilateral actions, such as walking, etc., are performed by one or other, of the first named parts. These facts imply that the two lateral halves of the nervous system, are associated together, and not this alone, but that some parts, are naturally more closely associated than

others. This association of the two halves together is effected by a system of commissural, or cross fibres.

There are two great functions of the nervous system, which are, in a certain sense, characteristic of it, namely, *sensibility* and *motility*. Corresponding to these two functions, there are two great anatomical tracts, the sensory and motor. In the peripheral nervous system, these two tracts are clearly separable, at least, at one point, viz.: where the cerebral, but more particularly the spinal nerves join the cord. At this place, as was first clearly pointed out by Sir Charles Bell, the motor fibres are collected into one bundle, and the sensory into another. They are called, as you know, the sensory and the motor roots of the nerves. This distinction, is to a certain degree, preserved throughout the whole course of the peripheral nervous system. In the cerebro-spinal axis proper, the distinction between the motor and sensory tracts, can be recognized at their extremes, but not at the lines of their contact, if such lines exist. That the anterior horns of gray matter in the spinal cord are chiefly motor, and that the posterior horns of gray matter, which are closely related to the sensory roots of the nerves are chiefly sensory, seems highly probable. Also in the base of the brain, there can hardly be a doubt, that the corpus striatum, and nucleus lenticularis, and associated parts are chiefly motor, while those basal ganglia, such as the thalami optici, and the corpora quadrigemina, which occupy a position behind the former, are in the main, sensory ganglia. And even in regard to the cortex of the brain, there seems to be some reason for thinking, that its posterior portion is mainly the seat of physiological and emotional sensibility; and the anterior, the seat of the higher portions of the motor tract, in conformity to the position it is known to occupy in the cord, and basal ganglia. Superimposed upon these two great tracts, of the nervous system, that can be traced through it from end to end and which constitute its frame work, we have at the cephalic end, certain other nervous organs, which are subservient to higher functions, more particularly those of intellection. In this latter complex of organs, the most refined portion of the sensory tract terminates, and here all sense impressions converge, that are destined to break fully into the sphere of

consciousness and to minister to our intellectual lives. Also at this same elevated point of the nervous system, the motor tract begins in those parts which are the immediate recipients of the stimulus of the will or of higher sensations or of the emotions and the *effects* of which stimulation may be transmitted through the entire extent of the motor tract, to its extremest limit.

Below this supreme point, the relations of the motor and sensory tracts,—where they obtain at all,—are immediate, and constitute the central mechanism of reflex action. But at the higher point I have mentioned, the relation is a mediate one, and the correspondence and interplay between the sensory and motor tracts, takes place usually through those parts which are the peculiar seats of mental action. This apparent divorce of the sensory and motor tracts from each other (physiologically speaking), is to the end that the sense impressions which reach the point in question, may be made instrumental in rousing the emotions,—moral, esthetic., etc., and for the purposes of thought, rather than that they should be at once expended, as they are lower down, in simply exciting, related portions of the motor tract, the outcome of which is reflex action, usually unconscious.

These two great tracts,—the sensory and motor,—with the parts auxilliary to them, make up the mass of the nervous system, whether peripheral or central, until we reach the brain, where, as already said, we find in addition another nervous apparatus superimposed, which is charged with the most exalted functions known to the animal economy,—the mental, and which may control many of the inferior parts of the nervous system, and through them the body in view of rational ends, often in spite of natural tendencies to contrary action, or inaction.

Now it is from every aspect of the case, important to trace if we can, the course and relations of these two tracts, not only in the peripheral but also the central nervous system. What parts of the cord, if any, are sensory, or are conductors of sense impressions upward towards the brain? What parts of the cord are either the seats of origin or the conductors of motor impressions? Upon what parts of the brain, if any, does the will act, to incite voluntary muscular motion, and when the

impression is once made, or the stimulus applied, exactly what course does it take on its way through the nervous mechanism, so as to reach the muscles? In what part of the cortex, if any, is the true center of perception for any given sense impression, or in correspondence therewith, where are the seats of action of the will, which initiates, conscious, rational, determinate action?

In case of disease of the nervous mechanism which leads to morbid phenomena in the spheres of sensibility, or motility or mental action, where is the seat of the disorder, as deduced from a knowledge of the parts of the nervous system, their mutual relations and functions?

Such are a few of the legitimate questions which arise to the thoughtful student, and they require an answer if possible. They are not simply speculative questions, they are thoroughly practical. The more you advance in your studies the more they will press on you.

Now it is my purpose to try and answer them, so far as they seem to me to be susceptible of answers, in the next few lectures. I shall try and point out established, from hypothetical questions as I pass along. But even the most hypothetical are to be regarded as something more than possible, as indeed in a degree probable. But want of absolute certainty should not deter us from going as far as we can, nor from the use of inference.

We will never make much progress in our knowledge of the nervous system, if we wait to be driven into it. The danger of a halting conservatism or of an unenterprising realism, though different in kind, are quite as real as those of a careless use of hypothesis.

I shall now proceed to describe in a more particular manner the modes of arrangement of the so-called gray and white matter of the nervous system.

Putting aside for the time, the extra-spinal ganglia of the vaso-motor nervous system, the gray matter may be divided into four great masses, the cerebral cortex, the basal ganglia, the central gray column or tube of the spinal cord, and that of the cerebellum and pons. This is essentially the method

of division adopted by Meynert, of Vienna. In the main it appears to me useful and correct.

1. The *cortex* is that vast corrugated layer of gray nervous matter, consisting mostly of cells, which is found on the surface of the hemispheres. It is composed of several layers, or strata, which ar separated by thin layers of white nerve substance, which consist largely of fibres. I will return to this subject, and describe the cortex with some particularity at a later period in our course.

2. The *basal ganglia* are situated in the base of the brain, and though they are connected with the cortex by fibres, as we will presently see, yet they are not continuous with it.

They include the corpora striati, the nuclei lenticulares, the thalami optici, the corpora quadrigemina, and besides these, many subordinate ganglia, generally small, which lie near these more important ones, and which I may refer to at greater length in a subsequent lecture. These ganglia are connected, as already remarked, with the cerebral cortex by nerve fibres.

3. The *gray column*, or *tube*, as it may be justly called, occupies the central part of the spinal cord, and medulla oblongata and is continued above along the under surface of the brain, as far forwards as the ventricular cavities extend. The spinal cord even in the adult human being has a central canal in its axis, which in some parts of its course is deficient, as on the back part of the medulla oblongata, where it is laid open from above, or behind, so as to expose the gray matter which invests it, and which, at the place in question, constitutes the floor of the fourth ventricle. But above this, the canal becomes once again complete as such, as the canal from the fourth to the third ventricle. Beyond this, it enlarges so as to constitute the floor and sides of the third ventricle.

In the cord and medulla this gray column has a layer of white matter, or nerve fibres, outside of it. Above the lower portion of the medulla, however, this gray column becomes irregular in shape, as already intimated, and has grouped about, and in close proximity with it, a large number of ganglia, which belong to the basal system. These ganglia are

connected with the gray tube by a system of fibres, to which reference is shortly to be made.

4. The *cerebellum* and pons, whatever other functions they subserve, seem to have as their chief office that of aiding in the co-ordination of muscular motions. The cerebellum has marked peculiarities of structure, and is situated outside of the regular motor tract, to which it is accessory. Either half of this organ has in its heart a nucleus of gray matter, inclosed in a mass of white nervous matter, or nerve fibres, which has in turn a cortex of gray matter, spread on its periphery, as in the case of the cerebrum. It is also thrown into very numerous and deep convolutions. The fibres of the white matter, beneath the cortex of the cerebellum, seem to connect it with the central gray nucleus already mentioned. Out of either half of the cerebellum three bands of fibres proceed, called *peduncles*, and named in their order from above downwards, superior, middle, and inferior. The first connect the hemispheres of the cerebellum with the hemispheres of the cerebrum, in a manner to be shortly described.

The inferior connects the cerebellum with the spinal cord, in a manner to be shown later in some detail. The fibres of the middle peduncle are continued forwards, in man, in a direction almost at right angles to the general course of the motor tract proper; in its descent from the corpus striatum, with which the fibres of the middle peduncle form connections, as well as with various detached nuclei of important motor nerves, for the purpose of regulating the distribution of the higher impulses to muscular action, especially such as originate in an act of the will.

The fibres of the middle peduncle contribute to the structure of the pons varolii, which includes other fibres not in immediate connection with the cerebellum, and very many clusters of nerve cells. The fibres of the middle peduncle place the cerebellum in intimate connection with the summit of the motor tract at a point just below the basal ganglia, in that part of its course which corresponds to the second projection system of Meynert. But I shall soon make a more detailed statement in respect to the structure and relations of

the pons. But you must not conclude that the cerebellum and pons include the whole apparatus for the co-ordination of muscular motions. No small part of it is to be found in the cord, especially its posterior columns, and as I am inclined to think, the anterior as well.

Such, then, in brief, excluding from consideration the ganglia of the peripheral portion of the vaso-motor nervous system, are the great masses of gray matter in the central nervous system, viz: the cerebral cortex, the basal ganglia, the gray tube, and the gray matter of the cerebellum.

But these masses of gray matter are not continuous as such, and yet they are intimately connected together. By what means? By systems of fibres. They may be classified into three or four great systems as they have been by Meynert. The first connects the cells of the gray matter of the cerebral cortex with those of the basal ganglia. These fibres partly compose the white mass of the interior of the hemispheres, and thus establish mutual relations between them and the basal ganglia. These fibres doubtless pass both ways,—to and from the cortex. They correspond mainly to the "projection system No. 1," of Meynert. Besides these fibres, the white substance of the hemispheres contains two other classes, viz.: 1. A system of fibres for associating the two halves of the brain together, chiefly comprised in the corpus callosum. These fibres probably associate a certain part of the cortex of the cerebrum on one side, with a corresponding part of the cortex on the opposite side. 2. A system of fibres which associate one part of the cortex on one side, with other parts of the cortex of the same side of the brain. But the system of fibres which I now desire to call particularly to your minds, is that which connects the cells of the cerebral cortex with the cells of the basal ganglia.

Then there is a system of fibres much less numerous than the last, which seems to connect the cells of the basal ganglia with those of the gray tube. These fibres are chiefly motor, since the channel in the gray tube for conveying sense impressions upwards to the basal ganglia, seems to be largely accomplished in its gray, rather than its white matter. The fibres of this system are chiefly contained in what are called

the lateral columns of the cord, and they vary greatly in their length. Some of them, soon after their origin in the cells of the basal ganglia, terminate in the cells of the cephalic end of the gray tube, while others terminate at various heights from its upper down to its lower end, thus placing each transverse section of gray matter in the cord in direct relation with the basal ganglia. Hence the lateral columns of the cord are very thick at their upper end, but become very thin at the lower end of the cord, as we might expect *a priori*, and as Stilling pointed out years ago, in his truly great work on the spinal cord, though the fact that he did so, seems to have been overlooked as a rule by anatomists and physiologists. The anterior and posterior columns are chiefly devoted to other purposes than the lateral columns, as I will endeavor to show hereafter. The system of fibres which I have just described corresponds to the second projection system of Meynert.

The third system of fibres includes almost the whole peripheral nervous system, and seems to connect the cells of the gray matter of the spinal cord with the non-nervous parts of the body, such as the integument, muscles, etc. This corresponds to the third projection system of fibres of Meynert. And lastly, we have the fibres which connect the cerebellum with the motor tract in certain parts of its course, and for certain purposes.

As regards the so-called sympathetic, or vaso-motor nervous system, its ganglia, or at least the larger and more central among them, are connected with vaso-motor centers situated in the whole length of the spinal cord, and the medulla oblongata. Nerve fibres pass out from the cells of these spinal vaso-motor centers, either in the trunks of the spinal and cranial nerves, or in the *rami communicantes* which connect the roots at least of the spinal nerves, with the ganglia of the fundamental chain of the sympathetic, or more properly, vaso-motor nervous system. The fibres collectively which connect the vaso-motor centres of the cord with the peripheral ganglia of the vaso-motor nervous system, pass both ways,—to and from the cord.

Those which pass from the cord outwards are divided by some, into two classes, *vaso-dilators* and *vaso-constrictors*,

while the fibres which pass towards the cord doubtless enter it, and connect with the cells of the vaso-motor centres there situate, as part of a reflex mechanism, within the confines of the vaso-motor nervous apparatus.

Such is a mere outline of the mechanism of the nervous system. In the next few lectures I will go at some length into details on this interesting subject.

(*To be continued.*)

ART. II.—LESIONS OF THE TRIFACIAL (ESPECIALLY FACIAL NEURALGIA), RESULTING FROM DISEASES OF THE DENTAL ORGANS AND ADJACENT PARTS.*

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MUCH has been written on the physiology and pathology of this important nerve, and much remains to be learned. The object of this paper is to bring more prominently to the notice of the profession a great source of neuralgia of the head and face. Without going at length into preliminary anatomical and physiological details respecting this fifth nerve, which must be known or readily accessible to all, I will commence at once with the subject.

Lesions of the Trifacial. (*Facial Neuralgia.*)

The term neuralgia is from the Greek *neuron*, a nerve, and *algos*, pain. Neuralgia is a *condition*, or *effect*, and *not* a *cause*—and refers to pain of a paroxysmal character—localized or metastatic, without manifestation of any lesion at its seat. The pains are nearly always unilateral; and usually follow the course of particular sensory nerves. The character of

* Read before the N. Y. Neurological Society, Jan. 3, 1876.